Site Selection for Estuarine Habitat Restoration: Model Criteria

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The Importance of the Estuary

Puget Sound rivers have broad flood plains that historically have contained relatively large areas of tidally influenced salt marsh and mud flat. In the past 150 years, we have destroyed over 70% of these salt marsh and mudflat habitats through diking, draining, and filling (White, 1997). Wild salmonid stocks are depressed throughout Puget Sound, and habitat loss, along with overharvest and hatchery practices, has been indicated as a primary factor in their decline. Chinook fingerling stop in the salt marshes and mud flats for weeks, and even months, to feed and gain strength for their ocean journey (Hayman et al., 1996). Because fish spawned over an entire river basin must pass through the estuary to enter the marine environment, healthy estuarine habitats are critical to salmon survival and production.

The Snohomish, Stillaguamish, and Skagit Rivers have no dams in the lower reaches that block salmon passage (like the Green and the Cedar), have not been moved from their native channels (like the Cedar and the White), and are lightly impacted by industrial development relative to the Duwamish and the Puyallup. These rivers, along with the Nisqually, the Nooksack, and the Elwha, represent the best opportunities we have to restore wild chinook runs in Puget Sound.

With this in mind, People for Puget Sound formed a partnership with the U.S. Fish and Wildlife Service Puget Sound Program and the Pacific Coast Joint Venture to model site selection for estuarine restoration in the Snohomish Delta. This paper explains the methods by which the project team selected and rates sites for our Snohomish Estuary Restoration Blueprint.

Estuary Habitat Restoration

The restoration of saltmarsh and mudflat habitat in Puget Sound is a very new science. Most of this kind of restoration has been accomplished in the 1990s on sites selected largely because of their availability. As readily available project sites have become scarcer, the need has grown for a way to assess the estuary from the point of view of resource needs. We set out to create a set of criteria by which entire river deltas could be screened to identify and prioritize potential intertidal restoration project sites based largely on ecological principles.

The starting point for developing our criteria was “Restoration of Urban Estuaries: New Approaches for Site Location and Design” by Schreffler and Thom (1993). While this report provided us excellent guidance, it did not reveal the site selection tool we were looking for. Our goal was to create a set of selection criteria that could be completed through field observation, interviews, and map and document research. We hope that we have developed a scientific tool that watershed groups can use without spending the time and money necessary for stringent scientific study.

We purposefully limited the consideration of social and political factors in our site selection protocol. We do believe they are real factors, but we believe that it is best to begin from a scientific base and then take advantage of the knowledge in the local community to further refine the rating of sites.

Developing the Criteria

We began by defining our project area as the extent of historic tidal influence in the Snohomish watershed. Snohomish County allowed us to use Geographical Information System (GIS) coverages produced through the 1995 Snohomish Estuary Wetland Integration Plan (SEWIP). We divided this geographical coverage into potential restoration sites that suggested themselves based on the meandering of sloughs and the placement of dikes. For the remaining sites, we developed our criteria based on basic ecological principles such as the role of habitat corridors and the relationship between site size and species diversity. The criteria award a maximum of four points for major considerations, fewer points for lesser considerations, and negative points for negative conditions. The criteria are detailed as follows:

1) Critical Habitat (0 to 4 points)

For the Snohomish estuary, we define the target habitat corridor as those sites adjacent to Ebey and/or Steamboat Sloughs.

- Within the target habitat corridor (2)
- Adjacent to current stem, channel, or slough (1)
- Adjacent to historic stem, channel, or slough (1)
- Entirely outside corridor with channels (0)

Discussion

For the estuary, the stems, channels, and sloughs are the primary corridor of travel for fish and wildlife. Since the Snohomish has high potential for wild chinook recovery, we decided to weigh our criteria in favor of salmon. (Coho also rely heavily on the estuary, and NMFS has announced their intentions to propose a coho listing.) In order to concentrate our efforts along one corridor, we awarded two points to sites directly adjacent the "target habitat corridor." For the Snohomish, it was logical to chose Ebey and Steamboat Sloughs as the habitat corridor, because it has the greatest amount of natural habitat in the lower Snohomish system.

It can be argued that we should have given higher priority to main-stem projects, since very little habitat exists there and it takes the highest river flow. However, salmon seek out side-channel habitat, and developing a continuous corridor would give salmon choosing that route a much higher likelihood of survival, as opposed to spreading risks and benefits out over the whole lower river system.

Since we are convinced that dike-breaching projects offer some of the highest benefit, we awarded one point to sites adjacent to a current stem, channel, or slough. We also awarded one point to sites adjacent to historic sloughs, in recognition of the potential for re-creating off-channel habitat in a place where it once existed.

2) Chinook Habitat Zones (0 to 2 points)

High-value chinook rearing habitat.

- Lower intertidal (2)
- Middle intertidal (0)
- Upper intertidal (2)

Discussion

An eight-year study, carried out in the Skagit estuary by the Skagit System Cooperative and nearly complete, shows that ocean-type juvenile chinook stop to feed there for extended periods (several weeks)—first in the upper portion of the estuary, and then in the lower. We divided the estuary into three equal portions and awarded two points to sites in the first or third portions. The divisions included mud flats at the lower end and non-saline waters at the top of tidal influence.

This criteria should be adjusted and refined as other salmon become listed (coho may rely heavily on the middle portion of the estuary) and as more research becomes available.

3) Percent Habitat Increase (0.2 to 4.0 points)

The potential increase in the total area of existing estuary habitat.

0–5%	(0.2)	21–25%	(1.0)	41–45%	(1.8)	61–65%	(2.6)	81–85%	(3.4)
6–10%	(0.4)	26–30%	(1.2)	46–50%	(2.0)	66–70%	(2.8)	86–90%	(3.6)
11–15%	(0.6)	31–35%	(1.4)	51–55%	(2.2)	71–75%	(3.0)	91–95%	(3.8)
16–20%	(0.8)	36–40%	(1.6)	56–60%	(2.4)	76–80%	(3.2)	96–100%	(4.0)

Discussion

This criteria is intended to equalize the relative value of sites from estuary to estuary by comparing the area of the site to the area of habitat already conserved and restored in the estuary. For instance, a two-acre site would score well in the Duwamish, but poorly in the Snohomish. For the Snohomish we calculated the existing estuary habitat at 1453 acres. For those target sites where the goal was not full restoration (such as dike setbacks on private land), we calculated their potential habitat area as the length of the site along a migration corridor (eg. slough) multiplied by a 150-foot restored buffer on the site. Our scale for rating this criteria is linear, with 0.2 points awarded for every 5% increase in habitat.

4) Site Area (0.33 to 4.0 points)

Habitat benefit based on area (in acres).

0–0.25	(0.33)	2.1–4.0	(1.66)	32.1–64.0	(3.0)
0.26–0.5	(0.66)	4.1–8.0	(2.0)	64.1–128.0	(3.33)
0.6–1.0	(1.0)	8.1–16.0	(2.33)	128.1–256.0	(3.66)
1.1–2.0	(1.33)	16.1–32.0	(2.66)	>256.1	(4.0)

Discussion

This area rating recognizes the fact that species diversity increases as the site area increases. With estuarine restoration, larger sites are more likely to provide elevations amenable to highly productive plants such as *Carex lyngbyei*, they are better able to bear outside pressures such as pollution invasive species, and they are more likely to be self-buffering against disturbances such as noise of lights. Larger sites can also present an efficiency of scale that can keep down the per-acre cost of restoration.

Since the relationship between size and benefit is nonlinear, we developed a scale base on the function $y = -36.392 + 19.596 \log x$ from Shreffler and Thom (1993) where y equals the number of wetland plant species and x is site area in square meters. Shreffler and Thom's analysis is only empirically valid for values of $x < 500\ m^2$. We have extended use of this equation beyond the empirical data because it yields an accelerated decrease in benefit for species numbers with increasing site area, a result that is intuitively and practically appealing. Because the validity of the function has not been determined for larger sites, we define y here to be the "size index" rather than species number.

Since doubling the area yields a linear increase in species number, we developed the index for sites ranging in size from a small urban restoration project (<0.25 acres) to larger rural projects (>250 acres). We assigned all sites above 256 acres the same value because Shreffler and Thom indicate that the size threshold for completely self-sustaining estuarine wetland is between 200 and 300 acres.

This method requires 12 geometric size steps to cover three orders of magnitude in site size. To convert the size index to a 0- to 4-point scale for evaluating potential restoration sites, we assigned each size step incremental values of 0.33.

The results of this analysis are shown below:

Site Area (acres)	Size Index	Scaled Value
>0–0.25	23.9	0.33
>0.25–0.5	29.8	0.66
>0.5–1.0	35.7	1
>1–2	41.6	1.33
>2–4	47.5	1.66
>4–8	53.4	2
>8–16	59.3	2.33
>16–32	65.2	2.66
>32–64	71.1	3
>64–128	77	3.33
>128–256	82.9	3.66
>256	88.8	4

5) Plant Community (0 to 3 points)

Presence is defined as 25% or greater coverage of the site.

- Non-native (Yes=1)
- Invasive (Yes=2)

Discussion

Since native animals are adapted to survive using native plants, this criterion awards points for the presence of non-native plants, based on the argument that manipulation of plant communities is often the most cost-effective type of restoration. One point is awarded when a site contains 25% or greater coverage of non-native plants such as pasture grass or crop plants. Two points are awarded for invasive species because they threaten the rest of the site and/or other sites and should be handled with more urgency.

6) Buffer (0 to 4 points)

Percentage of perimeter covered by at least a 100-foot depth of native vegetation or waterway.

0%	(0)
1–25%	(1)
26–50%	(2)
51–75%	(3)
76–100%	(4)

Discussion

Vegetated buffers are important because they can “trap excess sediments and purify water entering the aquatic system and function as a barrier to disturbance by noise, movement, etc.” (Shreffler and Thom, 1993, p. 53), and provide shade, cover and insects for juvenile fish. We have taken the minimum depth suggested by Shreffler and Thom (100 feet). For the highly impacted estuaries of Puget Sound, a 100-foot buffer anywhere along the perimeter of a restoration site would seem a luxury.

7) Restoration Ease (-2 to 0 points)

Not diked (0)

Diked, not filled (-1)

Diked and filled (-2)

Discussion

This criterion is designed to give weight to more cost-effective projects. A site under tidal influence with the presence of invasive species is likely to be cheaper to restore than a site that is diked and filled. It could be argued that invasive species are sometimes more costly per acre to remove or control. But in a case such as Port Susan, where *Spartina* exists and could spread to cover the entire perimeter of the bay and eventually spread around the Sound, the benefits cover the immediate area and beyond.

8) Impervious Surface (-4 to 0 points)

The percentage of the site that is impervious due to human action.

0%	(0)
1–25%	(-1)
26–50%	(-2)
51–75%	(-3)
76–100%	(-4)

Discussion

This criterion has the effect of further factoring the ease of restoration, since developed sites are more expensive to restore and have a higher chance of being contaminated. But this criteria is designed to take into account the fact that rating systems such as this one cannot assure that the best sites will actually be restored first. Impervious surface signals human habitation and/or business activity, and with this comes the chance that restoration proposals will meet with resistance. We hope that it will become more popular for landowners to restore portions of their land to habitat. But where unoccupied and developed sites exist, they should receive some priority.

Totals

For the Snohomish, we totaled the points and split them into three equal sections measured from the lowest score to the highest. We decided not to rate on a curve because we wanted a more "pure"" score that we could further adjust based on political and social factors known about particular sites—such as efforts already under way. The data are reported in Table 1 and the resulting GIS map in Figure 1.

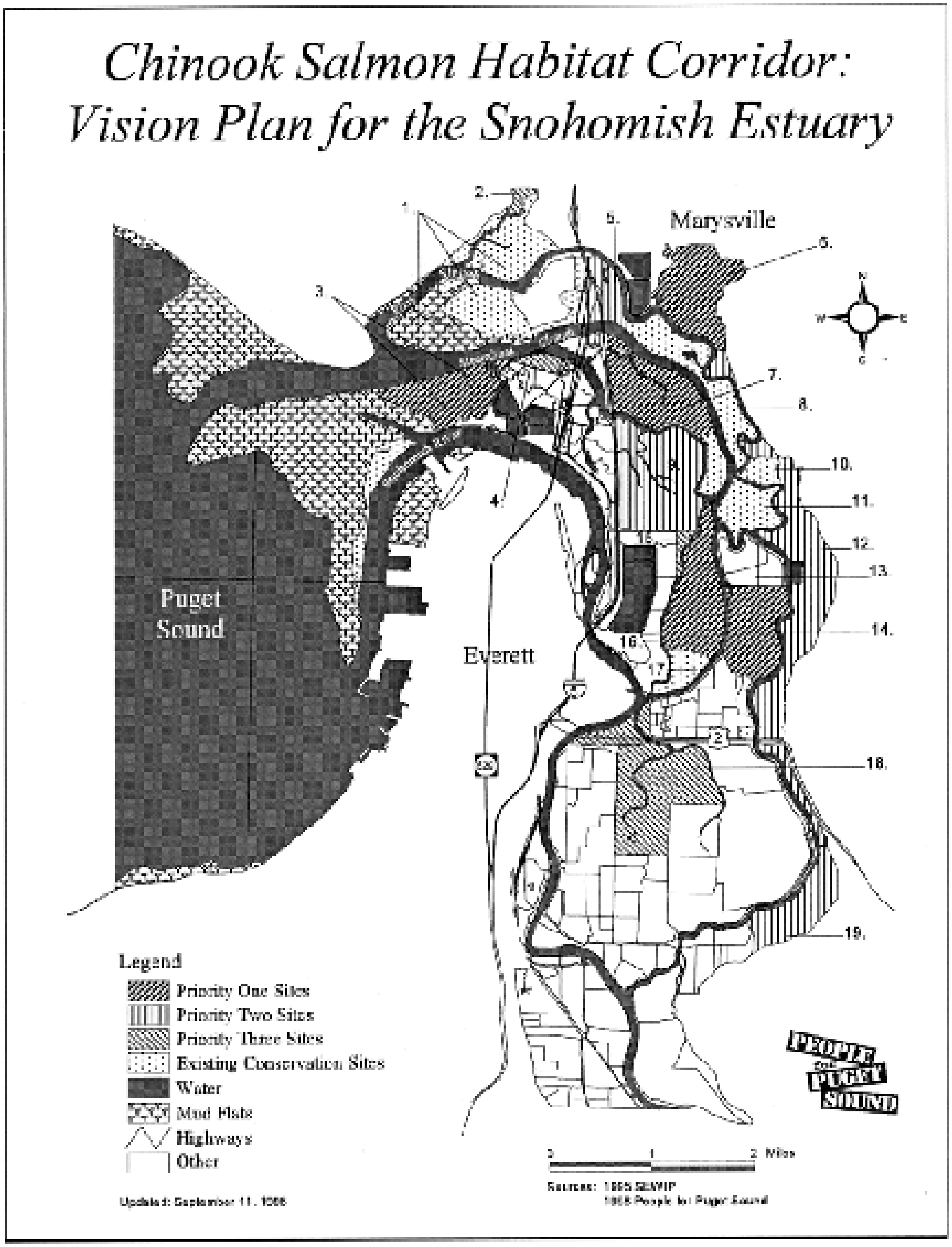

Figure 1. Chinook salmon habitat corridor: visitation plan for the Snohomish estuary.

Table 1. All sites considered in the study along with site scores developed from criteria and restoration priority resulting from the scores. Range for: priority 1 = 11.64–14.02, priority 2 = 9.25–11.63, priority 3 = 6.86–9.24. Sites already conserved and restored sites did not receive a score.

Site Number	Site Name	Site Score	Priority
2.	North Quilceda Creek	6.86	3
3.	Smith Island mud flat & salt marsh	11.8	1
4.	Smith Island Sliver	9.20	3
5.	Hayes Property	10.73	2
6.	Queloot	12.00	1
7.	Biringer Farm	14.00	1
8.	Mid Ebey Island		
9.	North Smith Island	11.40	2
10.	Nyman Property		
11.	Otter Island		
12.	East Ebey Slough	9.53	2
13.	South Ebey Island-A		
14.	South Ebey Island-B	11.80	1
15.	Smith Island Sliver	8.86	3
16.	South Spencer Palustrine	14.00	1
17.	South Spencer Estuarine		
18.	Deadwater Slough	5.53	3
19.	Drainage District Six	10.26	2

Conclusion

We believe that this tool, while simple, has the advantage of being extremely cheap and fast. The costs could be lowered further by using ratings produced by skilled volunteers. We plan to further test this system on other rivers, with the hopes of rating estuarine restoration sites in 12 major rivers around Puget Sound in the next few years.

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